

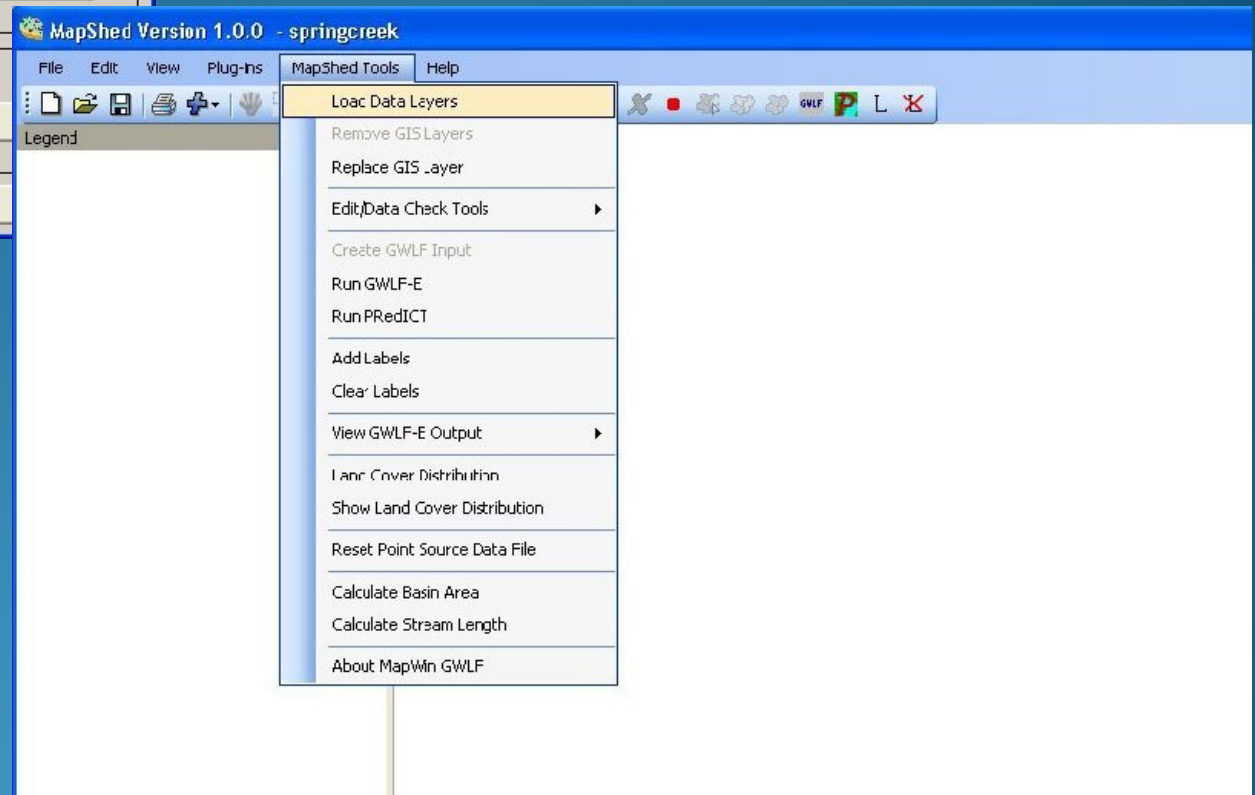
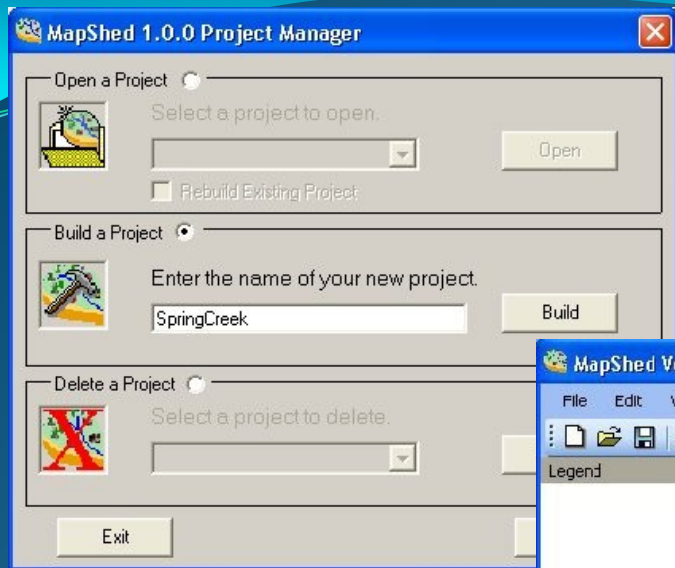
MapShed: A GIS-Based Watershed Modeling System

Dr. Barry M. Evans

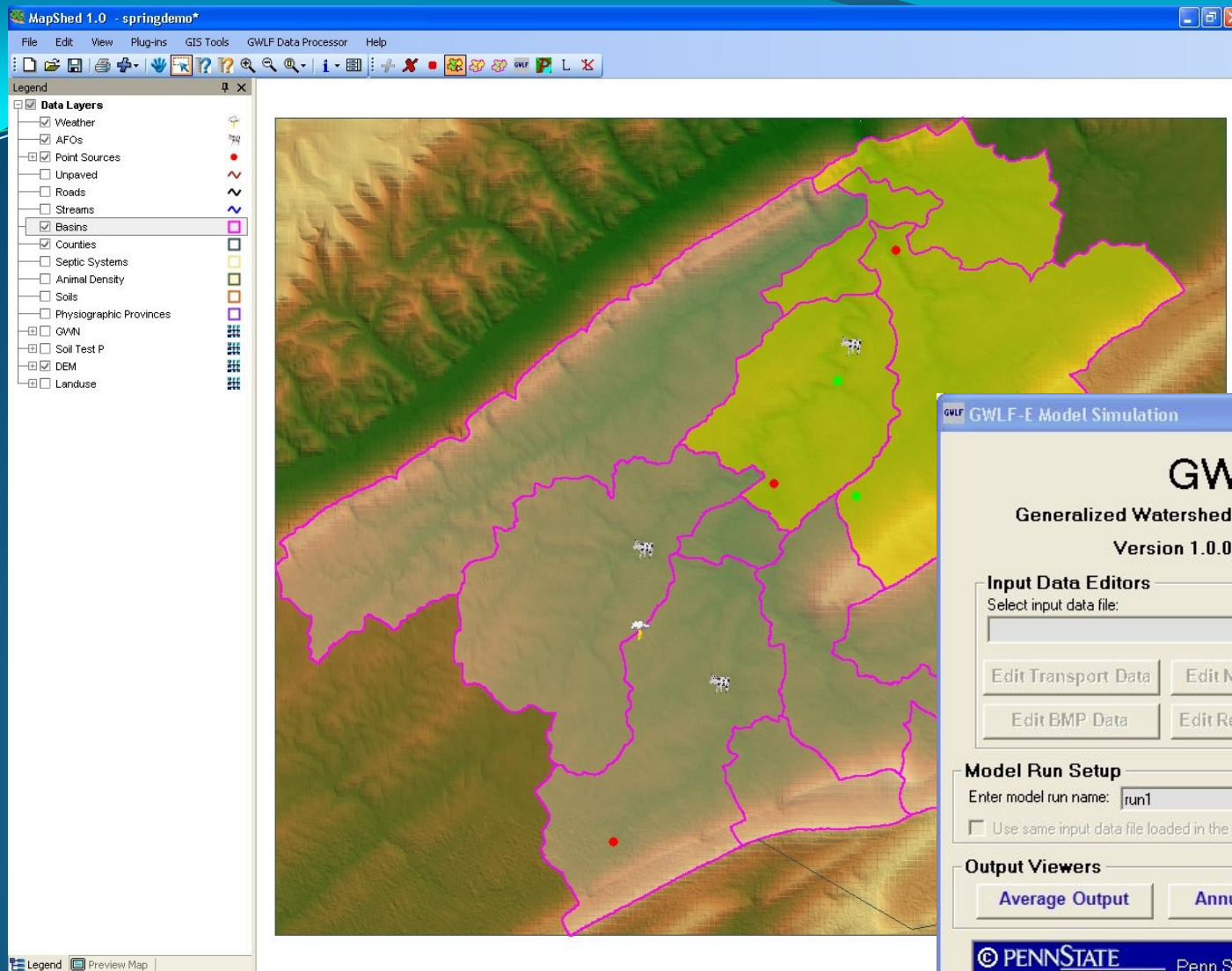
Penn State Institutes of Energy and the Environment
Pennsylvania State University

Brief History

- Core simulation model used is GWLF, which has been substantially enhanced over last 10 years (now GWLF-E)
- Initial modeling application developed using ArcView 3.x GIS software (AVGWLF)
- AVGWLF has been used by PaDEP and a number of other government and research organizations since 1999.
- Efforts to re-configure application to work in non-commercial GIS platform (MapWindow) began in 2010.
- First “official” version of MapShed set to be released to public by end of May 2011.



Use *MapShed* to create a project and load various GIS and weather data....



....then use *MapShed* to derive input data for the GWLF-E model

GWLF-E Model Simulation

GWLF-E

Generalized Watershed Loading Functions-Enhanced

Version 1.0.0, 2011 Edition (BETA)

Input Data Editors

Select input data file:

C:\MapShed\Runfiles\springcrk\springcrk_0.gms

Edit Transport Data **Edit Nutrient Data** **Edit Animal Data**

Edit BMP Data **Edit Retention Data** **Edit Weather Data**

Model Run Setup

Enter model run name:

☒ Use same input data file loaded in the input data editor.

Run GWLF-E

Output Viewers

Average Output **Annual Output** **Exit GWLF-E**

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Dissolved Runoff Coefficients (mg/L)

Rural Runoff	Dissolved N	Dissolved P
Hay/Pasture	2.9	0.18783
Cropland	2.9	0.18783
Forest	0.19	0.006
Wetland	0.19	0.006
Disturbed	0.012	0.0019
Turf/Golf	0	0
Open Land	0	0
Bare Rock	0	0
Sandy Areas	0	0
Unpaved Rd	2.9	0.2

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge			Septic System Populations			
	Kg N	Kg P	MGD	Normal	Pond	Short Cir	Direct
Jan	1971.22	96.2	0.6974	752	0	29	0
Feb	1780.46	96.92	0.6974	752	0	29	0
Mar	1971.22	96.2	0.6974	752	0	29	0
Apr	1907.64	93.12	0.6974	752	0	29	0
May	1971.22	96.2	0.6974	752	0	29	0
Jun	1907.64	93.12	0.6974	752	0	29	0
Jul	1971.22	96.2	0.6974	752	0	29	0
Aug	1971.22	96.2	0.6974	752	0	29	0
Sep	1907.64	93.12	0.6974	752	0	29	0
Oct	1971.22	96.2	0.6974	752	0	29	0
Nov	1907.64	93.12	0.6974	752	0	29	0
Dec	1971.22	96.2	0.6974	752	0	29	0

Urban Buildup (kg/Ha/day)

Area (Ha)	N	P	Sed
Groundwater (mg/L)	2.78	0.03	
Tile Drain (mg/L)	15	0.1	50
Soil Conc (mg/Kg)	2000	577	
% Bank Frac (0-1)	0.25	0.25	

Nitrogen

Acc Imp	Acc Perv	Dis Fract
0.095	0.015	0.33
0.105	0.015	0.33
0.11	0.015	0.33
0.095	0.015	0.28
0.1	0.015	0.28
0	0	0

Phosphorus

Acc Imp	Acc Perv	Dis Fract
0.0095	0.0021	0.4
0.0105	0.0021	0.4
0.0115	0.0021	0.4
0.0095	0.0019	0.37
0.0115	0.0039	0.37
0	0	0

TSS

Acc Imp	Acc Perv
2.8	0.8
6.2	0.8
2.8	0.8
2.5	1.3
6.2	1.1
0	0

Load File **Save File** **Export to JPEG** **Close**

Animal Data

Type	Number	Grazing	Average Wt.
Dairy Cows	110	Y	640
Beef Cows	20	Y	360
Broilers	225	N	0.9
Layers	225	N	1.8
Hogs/Swine	80	Y	61
Sheep	70	Y	50
Horses	15	Y	500
Turkeys	60	N	6.8
Other	0	N	0

Daily Loads (Kg/AEU)

N	P
0.44	0.07
0.31	0.09
1.07	0.3
0.85	0.29
0.48	0.15
0.37	0.1
0.28	0.06
0.59	0.2
0	0

Fecal Coliform

Orgs/ Day
1.00E+11
1.00E+11
1.40E+08
1.40E+08
1.10E+10
1.20E+10
4.20E+08
9.50E+07
0.00E+00

Manure Data Check

% Land applied: 0.8

% in confined areas: 0.2

Total (must be <= 1.0): 1.0

Initial Non-Grazing Animal Totals

N (Kg/Yr): 293

P (Kg/Yr): 95

FC (Orgs/Yr): 4.52E+10

NON-GRAZING ANIMAL DATA

Manure Spreading Contribution

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of annual load applied to crops/pasture	0.01	0.01	0.15	0.1	0.05	0.03	0.03	0.03	0.11	0.1	0.1	0.08
Base nitrogen loss rate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Base phosphorus loss rate	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
% of manure load incorporated into soil	0	0	0	0	0	0	0	0	0	0	0	0

Barryard/Confined Area Contribution

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Base nitrogen loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base phosphorus loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

Load File **Save File** **Create Files** **Export to JPEG** **Next** **Close**

Review and edit input data



Run the GWLF-E model

GWLF-E Hydrology for file: **spring1-2**

Period of analysis: **7 years from 1985 to 1991**

Units in Centimeters								
Month	Precip	ET	Extraction	Runoff	Subsurface Flow	Point Src Flow	Tile Drain Flow	Stream Flow
Jan	5.31	0.21	0.00	0.71	3.42	0.07	0.00	4.21
Feb	4.95	0.33	0.00	1.09	3.77	0.07	0.00	4.92
Mar	7.74	1.36	0.00	1.19	4.39	0.07	0.00	5.65
Apr	5.93	3.02	0.00	0.33	4.34	0.07	0.00	4.75
May	10.45	6.70	0.00	0.19	3.80	0.07	0.00	4.07
Jun	9.40	9.58	0.00	0.53	2.30	0.07	0.00	2.91
Jul	10.03	11.89	0.00	0.19	1.48	0.07	0.00	1.75
Aug	8.39	9.88	0.00	0.20	0.37	0.07	0.00	0.64
Sep	8.02	6.03	0.00	0.03	0.59	0.07	0.00	0.70
Oct	7.08	2.94	0.00	0.51	1.51	0.07	0.00	2.09
Nov	8.89	1.32	0.00	0.80	1.73	0.07	0.00	2.60
Dec	6.09	0.39	0.00	0.61	3.14	0.07	0.00	3.83
Totals	92.29	53.66	0.00	6.39	30.85	0.87	0.00	38.11

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GWLF-E Loads for file: **spring1-2**

Period of analysis: **7 years from 1985 to 1991**

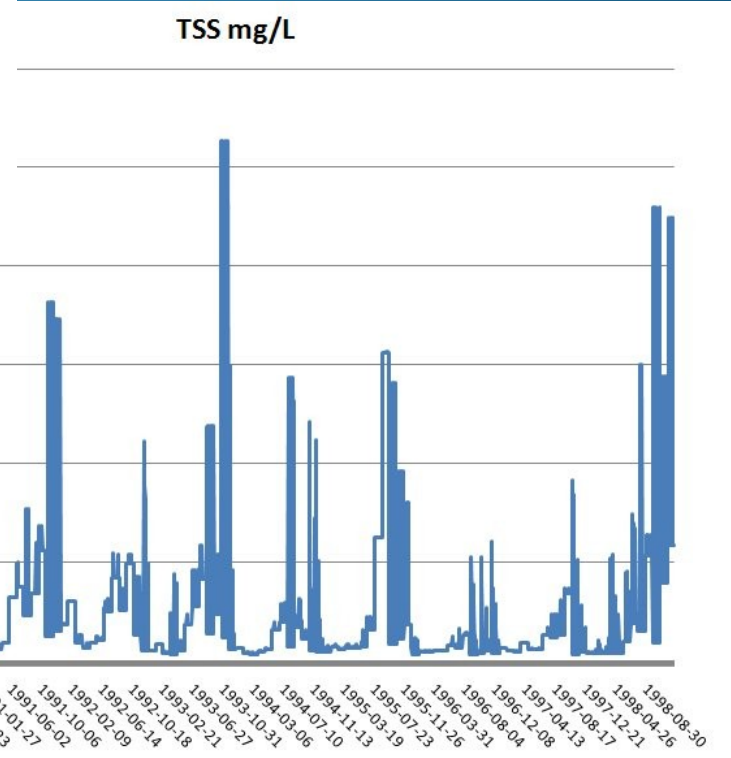
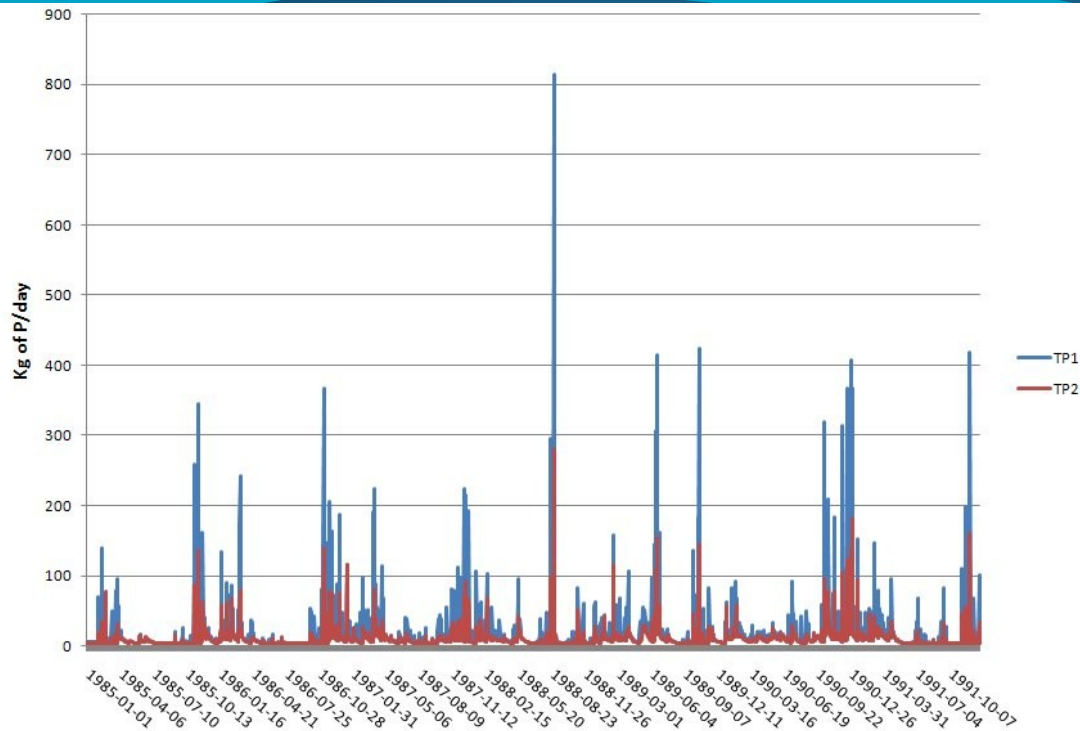
Month	Kg X 1000		Nutrient Loads (Kg)			
	Erosion	Sediment	Dissolved N	Total N	Dissolved P	Total P
Jan	1389.4	264.1	13748.0	14780.5	311.0	505.0
Feb	1432.2	328.1	15099.4	16023.5	338.4	532.8
Mar	841.4	391.4	17221.9	18516.8	474.0	661.9
Apr	1792.4	427.9	15882.4	16676.7	304.5	462.7
May	3695.1	294.7	14055.1	14550.7	262.4	361.2
Jun	3612.9	559.2	9823.2	10837.9	225.6	479.8
Jul	3705.9	239.3	6937.3	7598.5	181.4	302.2
Aug	3700.6	511.6	3499.7	4650.0	141.6	418.8
Sep	1177.9	111.6	3822.2	4081.2	124.2	179.9
Oct	1048.9	653.4	7370.5	8974.7	253.4	607.7
Nov	1956.9	1104.9	8423.6	11142.4	314.3	951.9
Dec	6788.9	1312.7	12634.5	15390.0	326.7	1035.6
Totals	31142.5	6198.7	128517.8	143222.7	3257.5	6499.4

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GWLF Total Loads for file: spring1-2		Period of analysis: 7 years from 1985 to 1991					
Source	Area (Ha)	Runoff (cm)	Kg X 1000		Total Loads (Kg)		
			Erosion	Sediment	Dissolved N	Total N	Dissolved P
Hay/Pasture	1285	3.6	1249.6	138.6	1230.2	1507.4	135.3
Cropland	2747	6.9	28970.9	3212.9	5017.4	11443.2	561.5
Forest	4892	3.0	650.8	72.2	278.2	422.5	8.8
Wetland	2	11.3	0.0	0.0	0.4	0.4	0.0
Disturbed	274	11.3	124.3	13.8	3.7	31.3	0.6
Turfgrass	0	0.0	0.0	0.0	0.0	0.0	0.0
Open Land	0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	7	11.3	146.8	16.3	23.0	55.5	1.6
LD Mixed	27	5.1	0.0	1.2	8.6	30.3	1.2
MD Mixed	456	18.9	0.0	106.8	757.3	2391.3	101.4
HD Mixed	444	28.2	0.0	104.0	737.3	2328.4	98.7
LD Residential	230	5.1	0.0	10.4	73.5	257.7	10.3
MD Residential	675	9.8	0.0	158.1	1121.0	3539.7	150.1
HD Residential	0	0.0	0.0	0.0	0.0	0.0	0.0
Farm Animals						765.9	343.5
Tile Drainage				0.0		0.0	0.0
Stream Bank				2364.6		1182.0	341.0
Groundwater					94799.4	94799.4	1030.5
Point Sources					23209.56	23209.56	1132.8
Septic Systems					1258.1	1258.1	24.7
Totals	11039	6.4	31142.4	6198.8	128517.8	143222.7	3257.5

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Various types of monthly and daily output created



All output written to Excel files to provide additional control in mangement and display of data.



Can use either GWLF-E or PRedICT to estimate load reductions from BMP implementation

RedICT - Project file name: gwlfdata-springbmp.dat Date: Jul, 2010

Rural Land BMP Scenario Editor

	Ha		BMP1	BMP2	BMP3	BMP4	BMP5	BMP6	BMP7	BMP8
Row Crops	2,747	% Existing	0	0	0	0	0	0	0	0
		% Future	0	75	0	0	0	50	0	0
Hay/Pasture	1,285	% Existing				0	0	0	0	0
		% Future				0	0	0	0	0

			% Existing	% Future
Agricultural Land on Slope > 3%	12	Ha	Total Livestock AEU's	93
			AWMS (Livestock)	0
Streams in Agricultural Areas	18.2	Km	AWMS (Poultry)	0
			Runoff Control	0
Total Stream Length	90.5	Km	Total Poultry AEU's	1
			Phytase in Feed	0
Unpaved Road Length	12.9	Km	Total AEU's	94

	Existing Km	Future Km
Stream Km with Vegetated Buffer Strips	0.0	18.2
Stream Km with Fencing	0.0	0.0
Stream Km with Bank Stabilization	0.0	0.0
Unpaved Road Km with E and S Controls	0.0	0.0

Note: Stream length (miles or Km) is equal to half of the total stream bank length with specified BMP.

Note: Stream bank stabilization can be applied to all streams in a watershed.

Note: Unpaved roads with E and S controls can be applied to all unpaved roads in a watershed.

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RedICT - Project file name: gwlfdata-springbmp.dat Date: Jul, 2010

Urban Land BMP Scenario Editor

High Density Urban

	Hectares	% Impervious Surface
Constructed Wetlands	1,575	50.0
% Existing	0	2
% Future	60	2
% Drainage Area Used	5.0	3.0
Impervious Ha Drained	472.5	0.0
CW Ha Required	47.3	0.0

Low Density Urban

	Hectares	% Impervious Surface
Constructed Wetlands	257	25.0
% Existing	0	0
% Future	0	0
% Drainage Area Used	3.0	2.0
Impervious Ha Drained	0.0	0.0
CW Ha Required	0.0	0.0

Stream Protection

	Existing	Future
Stream Km in high density urban areas	14.6	8.0
Stream Km in low density urban areas	2.0	0.0

Stream Km in high density urban areas w/buffers: 0.0

High density urban Streambank Stabilization: 0.0

Stream Km in low density urban areas w/buffers: 0.0

Low density urban Streambank Stabilization: 0.0

Back Next Export to JPEG Close Reset Defaults

Specify various BMP settings for a given scenario, and then run PRedICT to estimate potential load reductions

RedICT - Project file name: gwlfdata-springbmp.dat Date: Jul, 2010

Estimated Load Reductions

	Existing			Predicted		
	Total Sed	Total N	Total P	Total Sed	Total N	Total P
UPLAND EROSION / RUNOFF						
Row Crops	3,213,000	11,443	2,415	701,719	1,674	713
Hay/Pasture	139,000	1,507	215	139,000	1,507	215
High Density Urban	369,000	8,259	896	118,816	3,657	445
Low Density Urban	12,000	288	31	11,460	228	22
Unpaved Roads	16,000	56	11	16,000	56	11
Other	86,000	454	59	86,000	454	59
FARM ANIMALS		766	343		1,102	611
STREAMBANK EROSION	2,364,562	1,182	341	2,364,562	1,182	341
GROUNDWATER / SUBSURFACE		94,799	1,031		94,709	995
POINT SOURCE DISCHARGES		23,210	1,133		23,210	1,133
SEPTIC SYSTEMS		1,258	25		1,258	25
TOTALS	6,199,562	143,222	6,500	3,437,557	129,037	4,570
PERCENT REDUCTIONS				44.6	10.7	39.1
TOTAL SCENARIO COST	\$16,791,695.37					
Rural BMP	3.1%	WW Upgrade Cost	0.0%	Urban BMP Cost	96.6%	
Stream Protection Cost	0.3%	Unpaved Road Protection Cost	0.0%	Animal BMP Cost	0.0%	

“Before” and “After” results



Similar estimates of BMP reductions can also be simulated via use of the “Edit BMP Data” option in the GWLF-E model.....

GWLF Editing Data File: gwlfdata2

Rural Land BMP Scenario Editor

	Hectares	% Existing	BMP1	BMP2	BMP3	BMP4	BMP5	BMP6	BMP7	BMP8
Row Crops	2,749	% Existing	0	53	0	0	0	49	0	0
Hay/Pasture	1,286	% Existing			0	0	0	0	0	0

Streams in Agricultural Areas	18.2	Km	AWMS (Livestock)	0	% Existing
Total Stream Length	90.5	Km	AWMS (Poultry)	0	
Unpaved Road Length	12.9	Km	Runoff Control	0	
			Phytase in Feed	0	
			Stream Km with Vegetated Buffer Strips	4.5	Existing Km
			Stream Km with Fencing	0.0	
			Stream Km with Bank Stabilization	0.0	
			Unpaved Road Km with E and S Controls	0.0	

...but use of BMPs within GWLF-E model allows more options , and does better job of simulating flow changes (particularly with urban BMPs)

GWLF Editing Scenario File: gwlfdata2

Urban Scenario BMP Editor

Detention Basins

Detention basin volume (m³)

Basin dead storage (m³)

Basin surface area (m²)

Basin days to drain

Basin cleaning month

Stream Protection

Vegetative buffer strip width (m)

Fraction of streams treated (0-1)

Total streams in urban areas (km)

Streams w/bank stabilization (km)

Infiltration/Bioretenention

Amount of runoff retention (cm)

Fraction of area treated (0-1)

Constructed Wetlands

Total area urban land (Ha)

Fraction of area treated (0-1)

Street Sweeping

	Times/month
January	<input type="text" value="0"/>
February	<input type="text" value="0"/>
March	<input type="text" value="0"/>
April	<input type="text" value="0"/>
May	<input type="text" value="0"/>
June	<input type="text" value="0"/>
July	<input type="text" value="0"/>
August	<input type="text" value="0"/>
September	<input type="text" value="0"/>
October	<input type="text" value="0"/>
November	<input type="text" value="0"/>
December	<input type="text" value="0"/>

FDCC Tool

Flow Duration Curve Comparison Tool
for use with GWLF-E and MapShed
Version 1.0.0, 2011 Edition (BETA)

Initial GWLF-E analysis without BMPs:

GWLF-E analysis with BMPs:

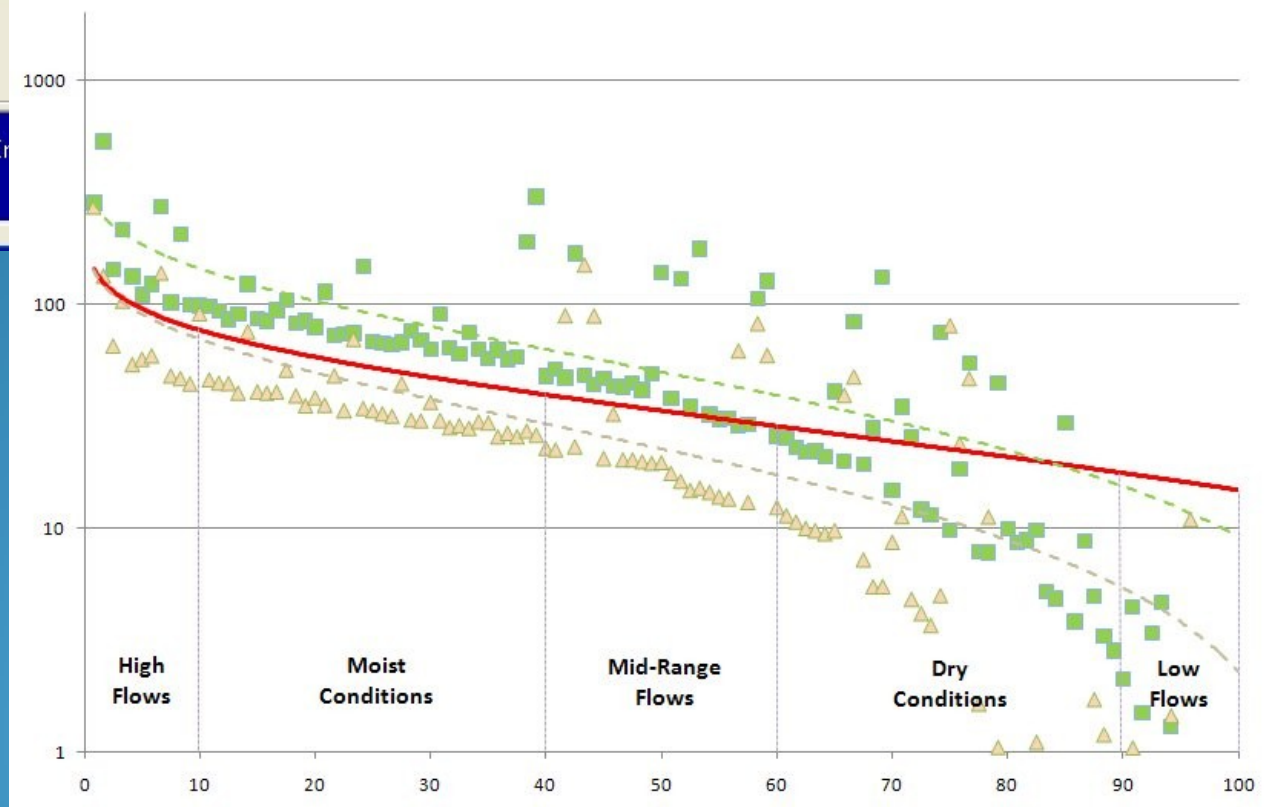
Enter a file name for this flow duration curve:

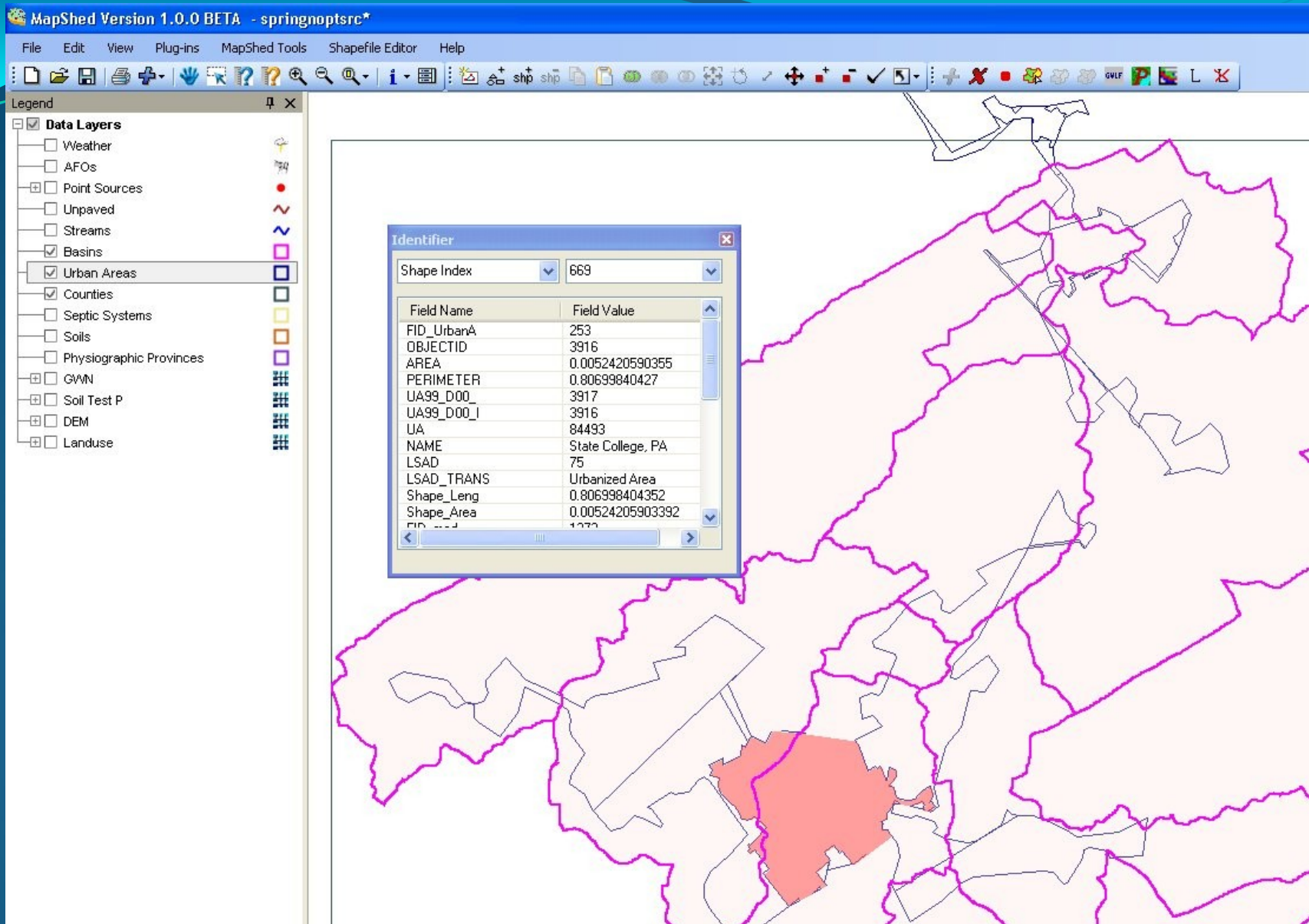
Select starting year:

Generate Curve

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New routine for comparing results of model runs against a user-generated flow/load duration curve.

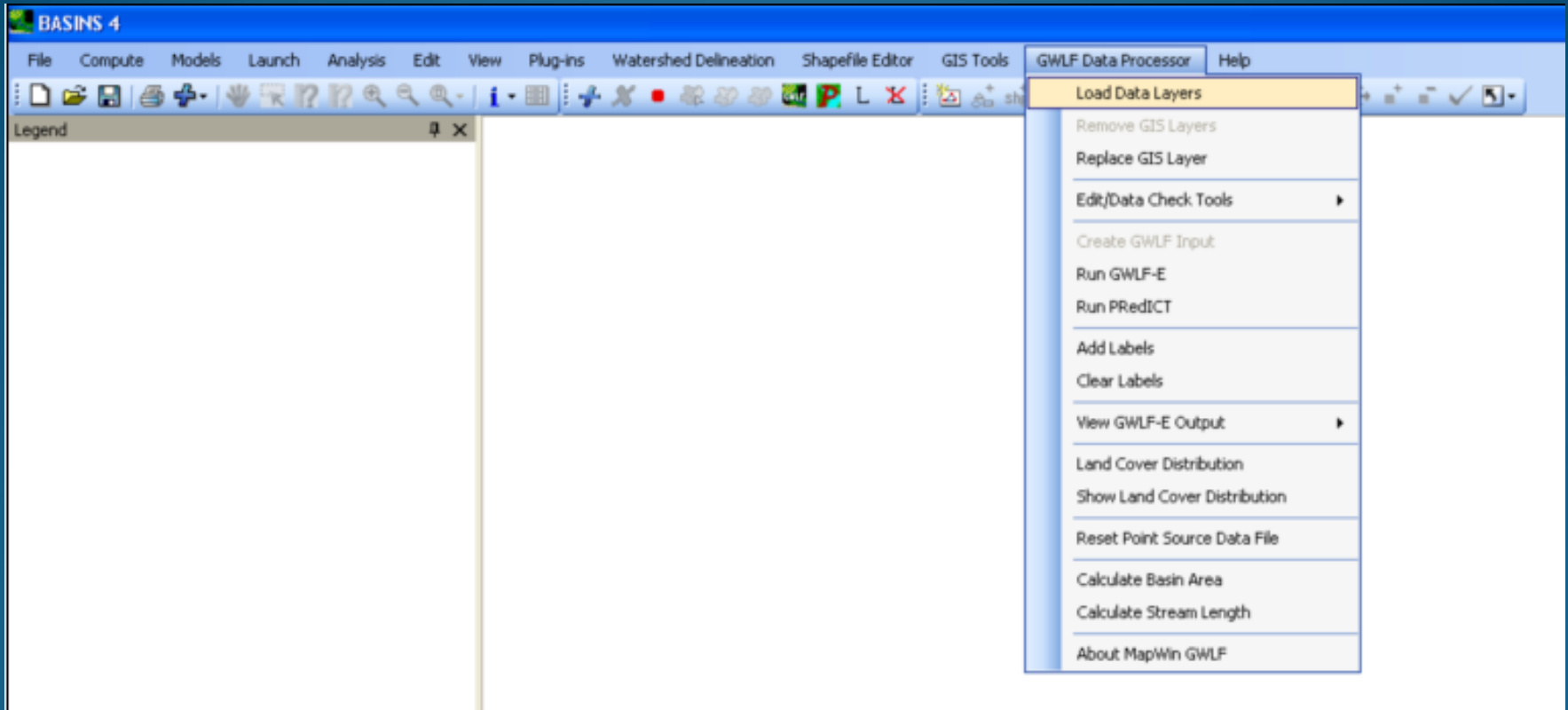




New MS4 load distribution function

	A	B	C	D	E	F	G	H
1	Number of Urban Areas	Watershed ID	Total Watershed Area (ha)					
2	5	0	11079					
3								
4	GvLF-E Average Loads by Source for Watershed 0							
5	Source	Area (ha)	Total Sediment Load (kg)	Sed Loading Rate (kg/ha)	Total Nitrogen Load (kg)	N Loading Rate (kg/ha)	Total Phosphorus Load (kg)	P Loading Rate (kg/ha)
6	Hay/Past	1288	178800	138.8	2368.05	1.84	335.92	0.26
7	Cropland	2750	4217140	1533.5	16163.31	5.88	3356.48	
8	Forest	4884	93160	19.1	852.22	0.13	69.12	0.01
9	Wetland	2	0	0	0.64	0.32	0.02	0.01
10	Disturbed	274	12000	43.8	30.65	0.11	8.06	0.03
11	Turfgrass	0	0	0	0	0	0	0
12	Open_Land	0	0	0	0	0	0	0
13	Bare_Rock	0	0	0	0	0	0	0
14	Sandy_Areas	0	0	0	0	0	0	0
15	Unpaved_Road	7	21040	3005.7	76	10.86	14.63	2.09
16	Ld_Mixed	26	980	37.7	23.61	0.91	2.53	0.1
17	Md_Mixed	457	80400	175.9	1780.67	3.9	194.24	0.43
18	Hd_Mixed	444	78110	175.9	1730.02	3.9	188.72	0.43
19	Ld_Residential	230	8680	37.7	208.82	0.91	22.42	0.1
20	Md_Residential	678	119280	175.9	2641.79	3.9	288.17	0.43
21	Hd_Residential	0	0	0	0	0	0	0
22	Water	39						
23								
24	Source	Total Sediment L	Total Nitrogen Load (kg)	Total Phosphorus Load (kg)				
25	Farm Animals		869.4	382.2				
26	Tile Drainage	0	0	0				
27	Stream Bank	2876064	1438	420				
28	Groundwater		112443.3	1222.2				
29	Point Sources		70666.5	3212.2				
30	Septic Systems		1500	27.3				
31								
32								
33	Average Loads by Source for each Urban Area							
34	Urban Area ID (FIPS Code)	Total Area (ha)						
35	5256	410						
36								
37	Source	Area (ha)	Total Sediment Load (kg)	Total Nitrogen Load (kg)	Total Phosphorus Load (kg)			
38	Hay/Pasture	13	1804.4	23.9	3.4			
39	Cropland	34	52139	199.9	41.5			
40	Forest	36	687.6	4.7	0.4			
41	Wetland	0	0	0	0			
42	Disturbed Land	0	0	0	0			
43	Turfgrass	0	0	0	0			
44	Open Land	0	0	0	0			
45	Bare Rock	0	0	0	0			
46	Sandy Areas	0	0	0	0			
47	Unpaved Roads	0	0	0	0			
48	LD Mixed	0	0	0	0			
49	MD Mixed	26	4573.4	101.4	11.2			
50	HD Mixed	87	15303.3	339.3	37.4			
51	LD Residential	2	75.4	1.8	0.2			
52	MD Residential	209	36763.1	815.1	89.9			
53	HD Residential	0	0	0	0			
54	Water	3						
55								
56	Source	Source Weighting	Total Sediment Load (kg)	Total Nitrogen Load (kg)	Total Phosphorus Load (kg)			
57	Farm Animals	0.037		32.2	14.1			

Loads from larger watershed proportionally distributed across urban areas based on areal extent



Basic routines within MapShed currently being added to BASINS 4.0 via use of MapWindow plug-in.

MapShed will soon be available for
download and testing at:

www.mapshed.psu.edu